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THE SIMULIIDAE OF THE ANGLO-EGYPTIAN SUDAN.

By D. J. Lewis, M.A., F.R.E.S.

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(Read 2nd June, 1948.)

With 1 Plate and 14 Maps.

Introduction.

Most of the Sudan is a vast shallow basin sloping towards the White Nile and the main Nile. In the east-central area the slope of the White Nile becomes very slight and the river flows through a clay plain, which probably represents a large ancient swamp into which the Nile and other rivers formerly flowed. Beyond Khartoum the Nile appears to have broken through the Sabaloka Gorge in ancient times (Ball, 1939) and now flows through the long "Cataract Reach," which may in a sense be regarded as the upper waters of a river flowing from Sabaloka to the Mediterranean. This conception of two rivers explains the otherwise puzzling fact that the lower part of the Sudan section of the Nile is heavily infested with Simuliids. In places the surface of the land is broken by scattered hills and mountains. Many thousands of years ago the climate became drier than before and the northern Sudan is now a desert and semi-desert area in which the Nile receives only two tributaries. There are three main areas in which Simuliidae flourish, (1) the western tributaries of the Upper Nile, (2) the main Nile below Khartoum, and (3) the Upper Blue Nile and Upper Atbara River areas.

Table I shows the 15 species, all those described being members of the subgenus *Simulium*, which are known in the Sudan. It may be noted that the much smaller area of Uganda has at least 30 species (Gibbins, 1937).

Descriptions of the species, or references to descriptions, are given by De Meillon (1930) and Gibbins (1941), and in other papers by these authors listed by Smart (1945).

In many areas the biting species are well known to the inhabitants and have names which are of value in discussing their prevalence. *S. damnosum* is known as *kunteb* near Abu Hamed (Balfour, 1906 ; Austen, 1906) and—in the southern Sudan—as *turluk* near Raga, *azire dupo* (hippopotamus flies) in Zande, *jor* in Ballanda, *tudu* in Ndogo and neighbouring languages, *amberagotanga* in Farogi, and *makwajagang* in Dinka at Wan Alel, and has several other local names which are useful for the purpose of making inquiries. *S. griseicollis* is known as *nimitti* in the Dongola area, but this word is sometimes used for Chironomidae in Khartoum.

TABLE I.—*Showing the Species of* Simulium *Present in the Sudan with a General Indication of their Known Prevalence in Streams and Rivers.*

	Southern Sudan.			Northern Sudan.	
	Above 1000 metres.	Below 1000 metres.			
		Streams.	Rivers.	Streams.	Rivers and a few canals.
S. adersi, Pomeroy, 1922	+	+	++	−	+
S. alcocki var. *henrardi* Gibbins, 1941	−	−	+	−	−
S. bovis De Meillon, 1930	−	−	++	−	−
S. cervicornutum Pomeroy, 1920	−	++	++	−	−
S. damnosum Theobald, 1903	−	+	++	−	++
S. dentulosum Roubaud, 1915	+	−	−	−	−
S. griseicollis Becker, 1906	−	−	+	−	++
S. impukane De Meillon, 1936	−	+	−	−	−
S. lepidum De Meillon, 1935	+	−	−	−	−
S. mcmahoni De Meillon, 1940	−	−	+	−	−
S. medusaeformis Pomeroy, 1920	+	+	+	−	−
S. nigritarsis Coquillett, 1901	+	−	−	−	−
S. ruficorne Macquart, 1838	−	+	−	+	−
S. unicornutum Pomeroy, 1920	−	+	+	−	−
S. sp. n. (undescribed)	−	−	+	−	−

All the Sudan species are mainly or entirely Ethiopian except *S. ruficorne*; this is an Ethiopian species which extends into North Africa and Palestine (Smart, 1946). Examples of discontinuous distribution are seen in the Simuliid fauna of the Nuba Hills, the Marra Mountains and the Erkowit area of the Red Sea Hills. It is not improbable that the species concerned (Maps 3, 7, 10, 11 and 12) were more widely distributed during the Pluvial Periods. Simuliids may be expected to occur at some high places on the Ethiopian frontier.

Artificial conditions have been responsible for the occurrence of Simuliids in the Gezira irrigated area and at the Jebel Auliya Dam (in 1937). SIMULIIDAE do not appear to be readily dispersed by artificial means in the Sudan. In an area heavily infested with *S. griseicollis* Dethier (1946) found comparatively few in aircraft. Nine of this species were found in an aeroplane from the north landing at Khartoum in February, 1936.

In most areas there is a *Simulium* season each year, and a season when the insects are scarce or absent. Generally speaking, in the northern Sudan the *Simulium* season is at the low river period, and in the south it is mainly during or after the flood season and before the rivers cease to flow.

S. damnosum and *S. griseicollis* bite man in the Sudan. Other Sudan species reported to attack man in some countries are *S. bovis*, *S. medusaeformis*, *S. adersi* and *S. nigritarsis*, but the last two are harmless in some places (Gibbins, 1941; Wanson and Millecamps, 1946). *S. dentulosum* is said to be very annoying in Uganda without biting. *S. lepidum* apparently does not attack man, its larvae being abundant at the Aga Falls, where biting Simuliids are unknown. *S. unicornutum* does not bite near Banningville in the Belgian Congo (Wanson and Fain, 1947).

S. damnosum is probably the vector of *Onchocerca volvulus* in the Sudan (Bryant, 1935; *East African Medical Journal*, 1939; Kirk, 1948). Bryant considered onchocerciasis to be responsible for the "appallingly

common " blindness of the Bahr el Ghazal Province, which constitutes a serious problem, and Cruikshank (1936) described the effects of the disease. Bryant believed that onchocerciasis also occurred east-south-east of Malakal beyond the frontier of Ethiopia. *S. damnosum* is a very troublesome biter in many parts of the Sudan, and the possibility of human onchocerciasis spreading to areas which are free of it should be borne in mind.

S. griseicollis is a serious pest in parts of the northern Sudan, where it occurs in immense numbers and attacks man and animals.

This paper deals largely with distribution, which in most areas was studied by collecting pupae. In the south this was done only in the dry season. Much remains to be learnt about bionomics and methods of control.

Early Observations.

It is possible that the first observations on *S. griseicollis* to be published were made on the Dongola Reach. Waddington and Hanbury (1822), after visiting Koye, near Sulb, on 21st January, 1822, wrote : "Many of the inundation flies were blown in our faces by the strong north wind, at the distance of two or three miles from the river."

Rüppell (1829), who visited Dongola in 1823, included notes on small flies in an account of climatic conditions. Even towards the end of February the temperature was once only 11° C. (expressed in degrees Réaumur) in the morning, with a fresh north wind, but he usually found that at sunrise it was 21°–23° C., and towards mid-day about 30° C. During calm weather the temperature increased and remained at 35° C. till 2 p.m. This warmth, Rüppell wrote, led to the development of a small fly, which at this season spread in innumerable swarms over the flat alluvial valley of the Nile. Myriads of these animals fell upon man and beast alike, penetrated eyes, nose and ears, and, with their proboscis-shaped mouth, caused painful irritation. Nothing gave protection against these harpie-like insects but smoke and darkness, therefore many natives were accustomed, for protection, to carry in their hands a piece of glowing cow-dung, the smoke of which enveloped the face. In the north wind these animals all gathered on the south side of thick bushes, and the thick, undulating, crowded masses afforded a strange sight.

De Cadalvène and De Breuvery (1836 : 344, 345), who travelled through Dongola in April, 1830, quoted part of Rüppel's observation, and also referred to the use of an ointment to mitigate the effect of the sun and drive away mosquitoes and other " vermine." In their vocabulary the word for insect is given as " nemittaminga " in the Mahass and " nemettigui " in the Dongola language.

The following reference by Hoskins (1835) is apparently to *S. damnosum* and is probably the first published note on this species. After visiting Gagi (Dagash ?), south of Abu Hamed, on 24th February, 1833, he wrote of " Ethiopian flies " : " On this evening, and also that of yesterday [at Abu Hamed] we have been annoyed by swarms of very small flies, like midges, which draw blood most copiously from our hands, but without leaving much painful irritation." Possibly he made light of the irritation or was insensitive to the effect of the bites. In a footnote Hoskins records that these flies annoyed cattle, but neither at Gagi nor on the Atbara had the effect described by

Bruce. He was evidently thinking of that great traveller's accounts of TABANIDAE.

Later travellers penetrated further towards central Africa, and it was apparently not till the present century that further observations were published when Balfour and King established the identity of the two northern species and recorded more about their habits. A " black sand-fly " at Kerri (Kiri ?) mentioned by Gordon (Hill, 1885 : 166) may perhaps have been *S. damnosum*. It is described as a night biter, but this species does bite until after sunset.

NOTES ON THE SPECIES.

Information on *S. damnosum* and *S. griseicollis* is given by Austen (1906, 1909), Balfour (1906) and King (1908, 1911, 1923), and is supplemented in the present paper in this section and in sections on the Dongola Reach and other areas. In the following distribution lists the specimens are those taken by the writer where no collector's name is indicated.

Simulium adersi Pomeroy.

This species was found on a tame hawk at Wad Medani in March, 1938, by Mr. W. Ruttledge.

Distribution.

Small stream 15 miles south of Rejaf, viii.29 (Edwards, 1930 ; Bequaert, J. C., 1938 ; Roubaud and Grenier, 1943) ; Pachala, S.E. of Malakal (*Dr. J. F. E. Bloss*) ; R. Bo near Rafile, Hawata, Heiban, Katire, Kuru, Maignbara, Mureibiya, Nkape, Rafile, R. Sueh near Tembura, Tonj, Wad Medani, Wau, Yei.

Simulium alcocki var. *henrardi* Gibbins.

Distribution.

R. Naam.

Simulium bovis De Meillon.

Distribution.

Amadi, Juba, Maignbara, Rafile, R. Sueh near Tembura (all on rivers).

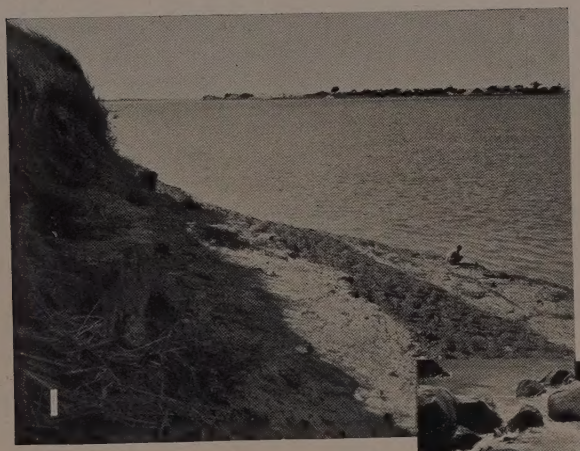
PLATE I.

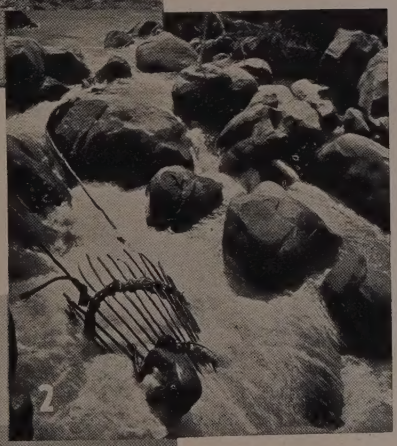
FIG. 1.—A breeding-place of *S. griseicollis* on a hard mud bank in slowly-flowing water (less than 1 km. per hour) at Debba in February, 1947 ; this photograph illustrates the extensive nature of the breeding-places and difficulty or impossibility of preventing breeding.

FIG. 2.—A large fish trap on the mooring ropes of which *S. damnosum* breeds (Mvolo, photo by Dr. J. F. E. Bloss). Comparison with fig. 1 shows the range of breeding-places of Simuliidae.

FIG. 3.—A place in the desert near Argo, where *S. griseicollis* was biting in February, 1947.

FIG. 4.—Protection against *S. griseicollis* in the Dongola area (photo by Dr. N. L. Corkill). The central man is wearing a veil ; the other three are wearing smouldering ropes on their heads and the boy is carrying smouldering rope.





D. J. Lewis. SIMULIIDAE *of the A.-E. Sudan.*

Simulium cervicornutum Pomeroy.

Distribution.

R. Eidi, Mabu, Maignbara, Meridi, R. Mongu, R. Naam, R. Sueh near Tembura, Yei.

Simulium damnosum Theobald.

J. Bequaert (1930) and J. C. Bequaert (1938) refer to a synonym described by Enderlein in 1922 from Khartoum specimens. In these specimens the antennae were ochraceous yellow and the flagellum had a grey bloom.

Distribution.

Abu Hamed, Nadi (" a veritable terror " at Abu Hamed, Balfour, 1906) ; Khartoum (Bequaert, 1930) ; Nkape falls (*Bloss*) ; Rafile, Kuru (*Dr. J. Bryant*) ; Gallabat (*G. M. S. Burton*) ; Shambat (*W. P. L. Cameron*) ; Damazin Rapids (*Dr. N. L. Corkill*) ; Nuri (*J. W. Cowland*) ; Mvolo (Gibbins, 1938) ; Mureibiya (*E. Jane*) ; Shereik, Third Cataract (King, 1911) ; Tonj, Wau (*Dr. F. L. Wheaton*) ; Abu Asha, Abu Fatima, Abu Haraz, Abu Usher, Amadi, Argo, R. Bo, El Bellal, Debba, Dongola, R. Duma, Hamdab, Kabodi, Kareima, Kawa, Khogali, Maignbara, Merowe, R. Naam S.E. of Meridi, Sabu, Sennar, R. Sueh near Tembura, Second Cataract, Tangasi, Tumbus, Uli I., Wad Arud, Wad Medani, Yei.

Some notes on annual and seasonal changes in abundance are included in the section on *S. griseicollis*. Two instances of apparently unusual abundance of *S. damnosum* may be mentioned here. Bryant (1935) refers to a report of exceptional numbers at Mvolo about 1910, and the Equatorial Province Diary for June, 1940, reports an unusual spread away from the rivers south of Aweil when they were unusually low.

Breeding habits.

After examining specimens of pupae from the Sudan the late Mr. E. G. Gibbins remarked in a letter on the large proportion of *S. damnosum*. Gibbins (1933) found that *S. damnosum* only bred in the most turbulent waters, and the rapids pictured by him in his Plate IV are a contrast to many Sudan breeding places in which the water surface is nearly as calm as in Plate I. Wanson and Henrard (1945) found that the larvae were confined to rapids and to currents of over 3 km. per hour. In the Sudan, although *S. damnosum* breeds mainly in rapids, it can breed on mud in relatively placid water flowing at about 2 km. per hour. In a small river at Yei pupae were found near those of *S. alcocki* var. *henrardi* and *S. unicornutum*, species with which Wanson and Henrard never found it associated. Evidently *S. damnosum* has a much wider range of breeding places than in Central Africa. It breeds in many of the larger streams, in the rapids of many rivers and even in some navigable parts of the main and Blue Niles. In the south pupae are sometimes found in large numbers on the cords used to anchor fish traps in rapids, and often occur on stranded fragments of plants and on *Dicrania* sp., a moss-like plant which grows on rocks and is a member of the PODOSTEMACEAE, species of which form breeding sites of Simuliids in the Congo (Wanson and Henrard, 1945). At Sennar they breed on trailing *Phragmites* sp. and at Wad Medani on sedge. Wanson and

Henrard (1945) found that in the Belgian Congo the presence of pupae in clusters was characteristic of *S. damnosum*, but in the Sudan *S. griseicollis* and *S. lepidum* have also been found in clusters. Pupae of *S. damnosum* have been taken at a depth of 60 cm. at Dongola.

Habits of the adults.

In the Sudan *S. damnosum* appears to behave as it does in other countries. It is well known that it has great powers of flight and prefers wooded to open country. On the Sueh and Blue Nile rivers it is a common experience to find no adults near breeding-places, but many biting beneath trees out of sight of any rapids. At Hamdab, several kilometres from a large breeding area in the Fourth Cataract, biting adults are common in the barren rocky desert, and in several other northern areas adults have been found biting in places completely devoid of vegetation.

S. damnosum has been seen to attack donkeys.

Simulium dentulosum Roubaud.

Distribution.

Marra Mts. (*D. Taher*); Katire, Nagichot.

Simulium griseicollis Becker.

This species normally feeds little on man, but is a notorious pest in the Dongola area where it occurs in immense numbers. The insects crawl on the skin, causing great annoyance, and the small percentage which bite are in fact numerous. The writer has made one tour of the Dongola area, but the year proved to be one of unusually few nimitti.

Distribution.

Nadi (*Bloss*); Abu Fatima, Argo, Khandaq, Khartoum (Gibbins, 1935); Selim (1910), Shambat, Umm Inderaba (Gibbins, 1938); Abu Hamed, Abu Hamed to Khartoum along river in winter, Debba, Jebel Umm Ali, Merowe, Third Cataract (King, 1908); Abbassiya, Abri, Affat, Akasha, Argi I., Atbara, Attab, Delgo, Dongola, Fergi, Hamdab, Hawata, Hetani, Jebel Auliya, Juba, Kawa, Kulud, Kurru (near Merowe), Magadib, Megauda, Mograkka, Rafile, Sabu, Sadinfanti, Second Cataract, Suarda, Tangasi I., Tumbus, Wau, Wawa, Wad Medani.

S. griseicollis is widely distributed in the Sudan along the lower parts of the main and Blue Niles, but has only been found in a few places in the South. Although a widely distributed Ethiopian species common in parts of West Africa (Roubaud and Grenier, 1943), it is evidently most abundant in the Sudan near the border of the Palaearctic Region. In the breeding season it is common between Merowe and Abri, and extremely abundant between Kulud and Wawa.

Abundance in the Dongola area.

In most years nimitti become so abundant that they are said to form a vast smoke-like all-pervading cloud out of doors so thick that it can be felt by swinging the arms. When the writer visited Dongola in February, 1947, every

cubic metre of air contained many nimitti and, at least near trees, the cloud appeared to rise to 20 metres or more above the ground. There were probably several hundreds of millions in the town, yet all inhabitants questioned either said that there were no nimitti or that they had scarcely begun to increase. In 1947 there was an exceptionally light infestation, but when the insects are at their greatest abundance the area between Kulud and Kerma is probably covered by a cloud of many thousands of millions, stretching out into the desert on each side of the river. Observations on breeding conditions partially explain the vast numbers.

Annual variation in numbers.

Apart from the fluctuations in numbers of *S. griseicollis* and *S. damnosum* responsible for the occurrence of *Simulium* seasons on the main Nile each year, there are wider fluctuations manifested by "*Simulium* years" which are remembered by the inhabitants. Without regular observations over a long period it is impossible to ascertain the causes of the fluctuations. The winter of 1923 is said to have been bad for *Simulium* at Merowe and that of 1936 at Shambat, where nets were used. The 1939–40 season was bad at Sennar, Abu Haraz, Shambat, Merowe and Gureir. At Dongola there were few Simuliids in the winter of 1938. Some *Simulium* years have probably passed unrecorded. Examination of records of the Nile levels shows no striking correlation between high or low levels with *Simulium* years except in 1946–47, when the level was continually above the average after the great 1946 flood, and the nimitti were said to be the fewest for many years. The abundance of *S. damnosum* in a presumably low river year in the south-west has been mentioned. It seems probable that local outbreaks of *Simulium* may often be due partly to river levels remaining at the level of local sedge banks and rocky ledges.

It is said that in one year Simuliids were troublesome in the Second Cataract, an area which may, perhaps, be often too cold for breeding.

Breeding habits.

S. griseicollis breeds mainly in rivers rather than streams, and usually in unbroken water. Larvae and pupae have been found on sedge, roots, sticks, stones and other objects in the water, but the main breeding surface in the Dongola area appears to be moderately hard mud in water flowing as slowly as about 0·8 km. an hour. Dense clusters of pupae were found by the writer at a depth of 75 cm., and others were probably present at still greater depths. The pupae were frequently situated in the entrances of the numerous tunnels occupied by caddis larvae. Occasionally two pupae have been seen facing in opposite directions on one leaf.

General habits of the adults.

By day many males and females can be seen resting on vegetation near Dongola, sometimes many on a single head of corn. At night the adults do not bite and most disappear from the vegetation. Great daytime clouds of Simuliids seen in February, 1947, appeared to consist mainly of males, flying as it were, in an immense swarm but not localized at any particular points. Swarms which occur later in the season are said to consist of females (King,

1908). Of 41 adults caught flying at Megauda on 16th February, 1947, in the afternoon, 31 were females. The females can easily be collected as they swarm round people and on hats.

Feeding habits of the females.

The females walk over the skin and probe for some time, causing much annoyance and irritation. It is a remarkable fact that a relatively very small number become engorged. In five females observed this process occupied from 4 to 16 minutes, although specimens observed by Roubaud (Roubaud and Grenier, 1943) became engorged on a freshly killed bird in a few instants. The reluctance or inefficiency of this species in sucking human blood is emphasized by the fact that not long ago (Gibbins, 1938) it was not generally known that it could do so, although King (1923), writing of the Spanish Sparrow, had reported *S. griseicollis* sucking human blood. This has also been recorded by Wanson and Fain (1947) in the Belgian Congo. Unlike *S. damnosum*, *S. griseicollis* mainly attacks the upper part of the body, particularly behind the ears, engorges slowly, is not easily disturbed, and does not leave a drop of blood at the site of the puncture. The nimitti crawl into sun helmets and bite in the hair. When numerous they bite various parts of the body, particularly along the collar and hat-band.

S. griseicollis readily feeds to repletion on birds and donkeys, causing the death of captive pigeons, hawks and parrots, and occasionally donkeys (King, 1923). Roubaud has seen it suck blood from a horse. When not very numerous it appears to attack birds rather than donkeys and cattle. King (1923) regarded this insect as the only important local natural enemy of the Spanish Sparrow, a pest of grain, and considered that it probably prevented the birds from feeding freely on the corn. He found that the nimitti were very plentiful in the Argo area in March, 1920, and thought they were probably responsible for an enormous mortality of Spanish Sparrows in the Akasha-Saras area on their northward migration, and for a marked diminution in the number of sparrows returning in the winter.

Mr. J. G. Mavrogordato informs me that nimitti have often attacked his tame falcons in Khartoum, biting them mainly on the cere and the bare skin near the eye and to some extent on the feet. The insects seldom bit indoors, and did not bite beneath the leather hoods of the birds. Mr. Mavrogordato himself and his tame owl and parrot were not attacked. People can escape the bites of nimitti, unless they are very numerous, by staying indoors.

S. griseicollis, like *S. damnosum*, bites during twilight, but not after dark.

Range of flight.

S. griseicollis can travel considerable distances, possibly aided by the wind. It is not troublesome in a moderate breeze and is probably not a strong flier. It is commonly observed in the desert near Dongola in sufficient numbers to cause annoyance (Plate I, fig. 3), and has been reported from Bir el Farid 18 km. from the Nile. It was found at Umm Inderaba in January, 1929, over 80 km. from its probable breeding-place on the main or Blue Nile. Edwards, Oldroyd and Smart (1939) state that it " has been found numerous in places as much as 200 miles distant from its home in the river Nile " in the Sudan, but

I am informed by Mr. Oldroyd that the source of the record, inserted by the late Dr. Edwards, is not known. It seems possible that the record was made not very far from breeding-places on mud at a time when this breeding site was unknown.

Simulium impukane De Meillon.

Distribution.

R. Ya.

Simulium lepidum De Meillon.

Distribution.

Aga Falls (1100 metres), Gilo, Katire.

Simulium mcmahoni De Meillon.

Distribution.

Yei.

Simulium medusaeformis Pomeroy.

Distribution.

R. Naam (*Bloss*); Marra Mts. (*Taher*); R. Eidi, Mabu, R. Sueh near Tembura, R. Tori, R. Ya, Yei.

Simulium nigritarsis Coquillett.

Distribution.

Marra Mts. (*Taher*); Gilo (1400 metres), Katire (1100 m.), Nagichot (1980 m.).

Simulium ruficorne Macquart.

Distribution.

Erkowit (Gibbins, 1938); Talodi, 7th October, 1928 (Gibbins, 1941); Heiban, Kororak, Kuru, Sheikh Karim, Yei.

Simulium unicornutum Pomeroy.

Distribution.

R. Eidi, R. Naam, R. Sueh near Tembura, R. Ya, Yei.

Simulium sp. n.

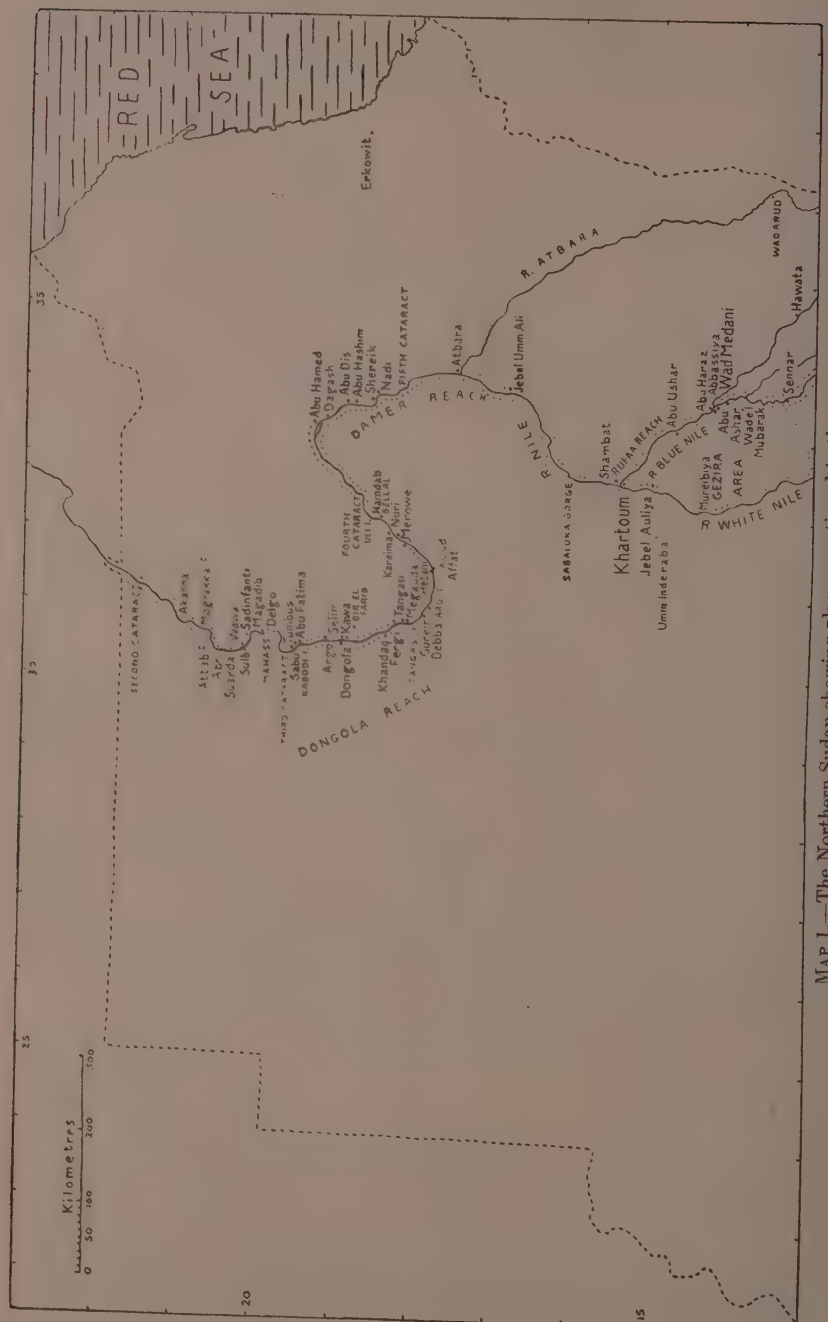
The pupa has bilobed respiratory organs. Adults have not yet been obtained.

Distribution.

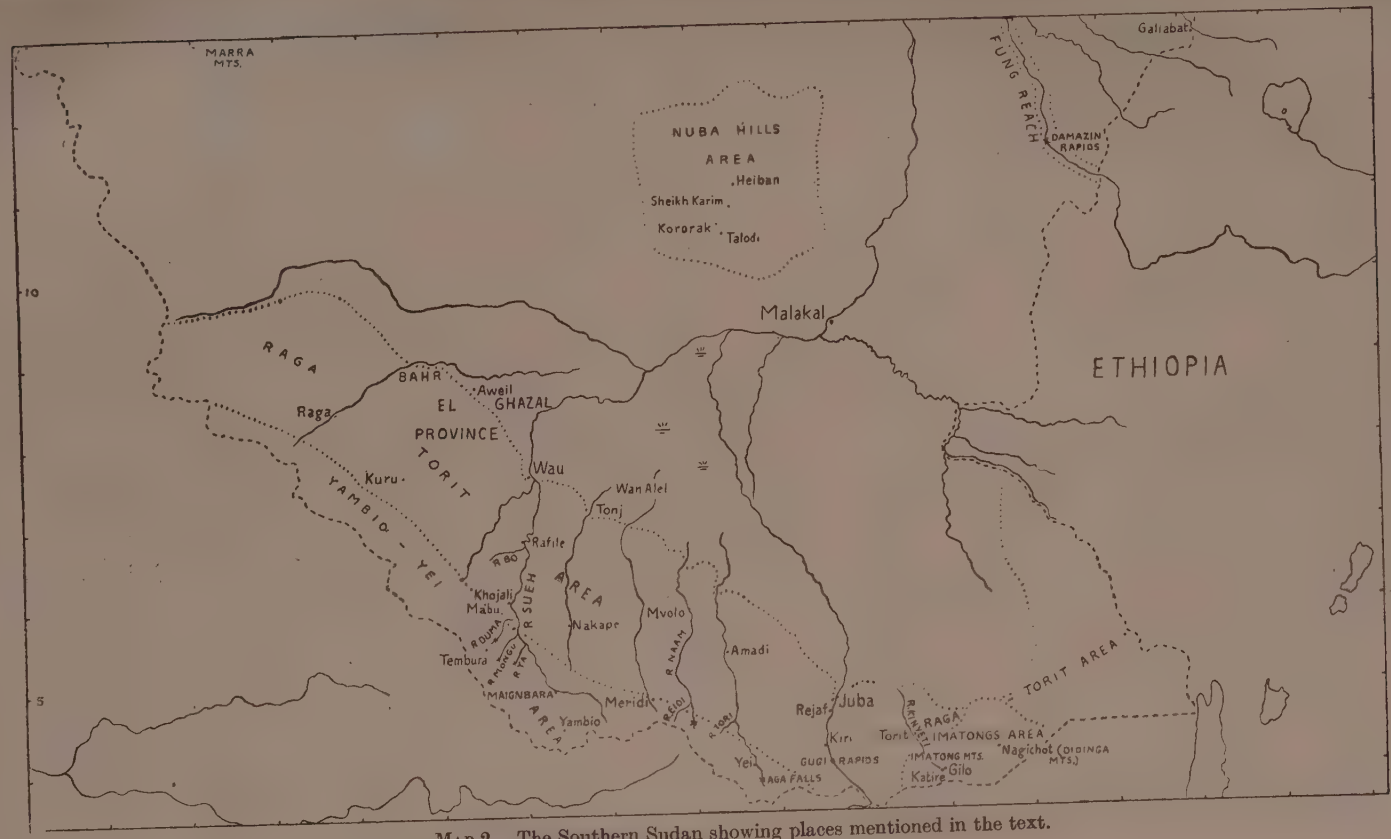
Maignbara, Rafile, Wau (all on R. Sueh).

Notes on Areas.

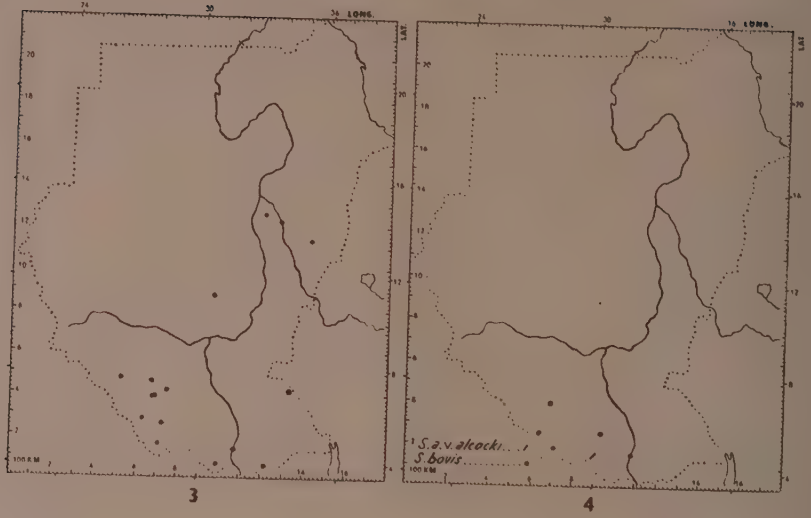
The main areas in which Simuliidae occur are indicated by dotted lines in Maps 1 and 2. They are taken from a faunal map drawn by Lewis (1947), except for the Damer and Dongola Reaches. The name of the former has been

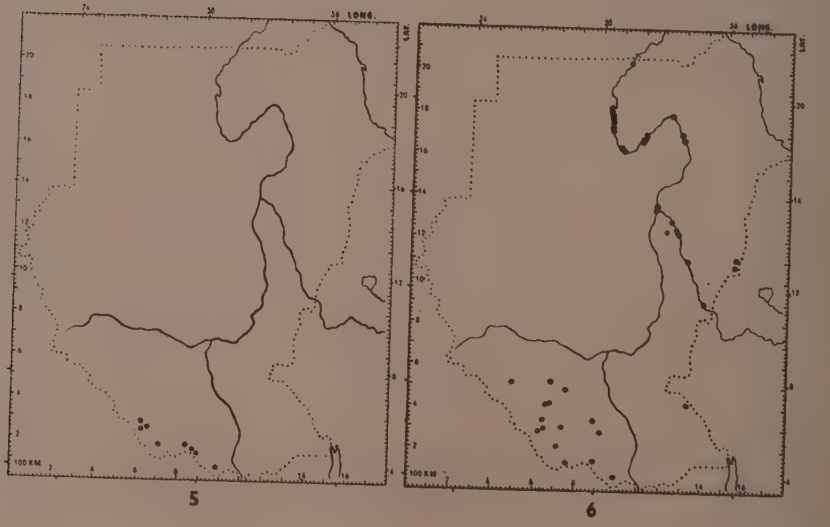


Map 1.—The Northern Sudan showing places mentioned in the text.

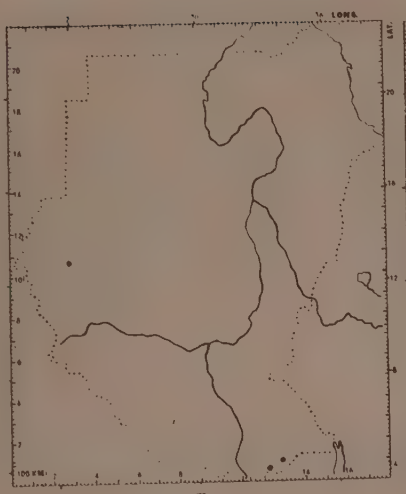


MAP 2.—The Southern Sudan showing places mentioned in the text.





MAP 3.— *S. adersi.*
MAP 4.—*S. alcocki* var. *henrardi* and *S. bovis.*
MAP 5.—*S. cervicornutum.*
MAP 6.—*S. damnosum.*



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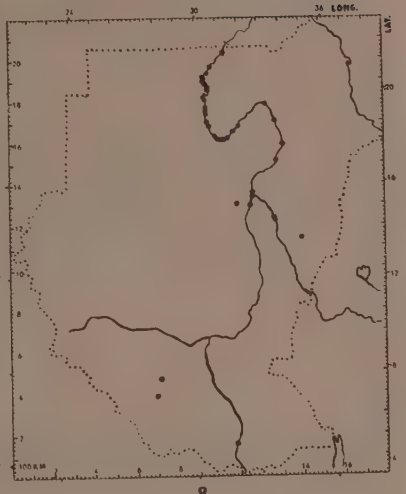

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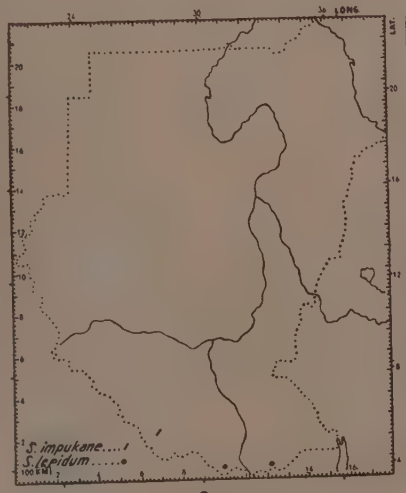

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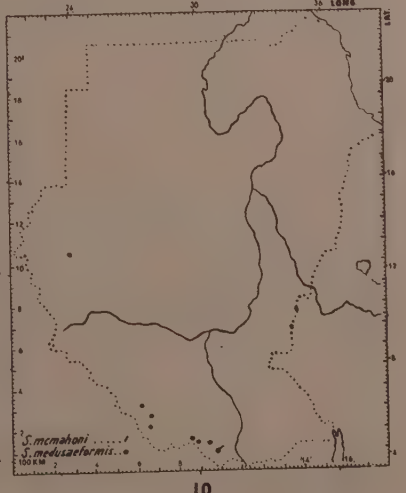

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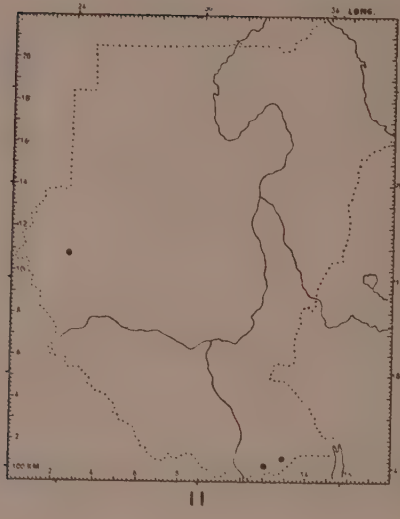
MAP 7.—*S. dentulosum.*
MAP 8.—*S. griseicollis.*
MAP 9.—*S. impukane* and *S. lepidum.*
MAP 10.—*S. mcmahoni* and *S. medusaeformis.*



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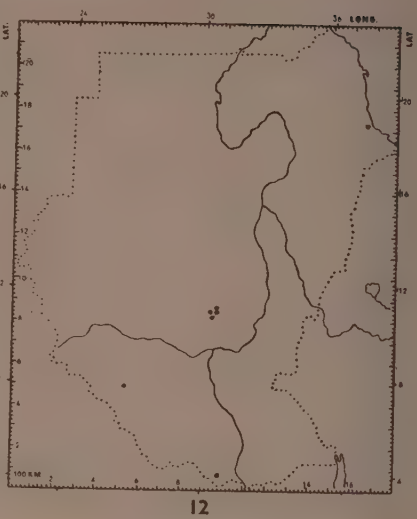

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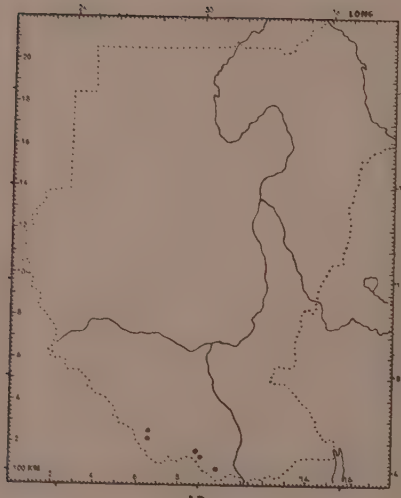

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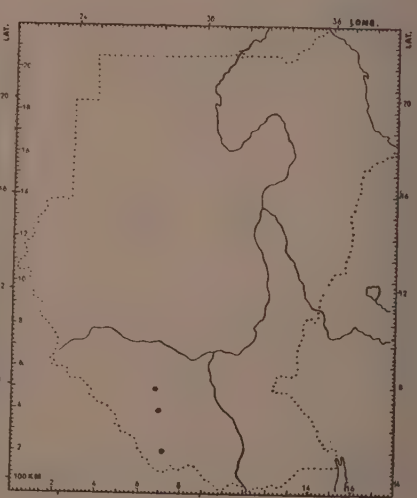

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Map 11.—*S. nigritarsis.*
Map 12.—*S. ruficorne.*
Map 13.—*S. unicornutum.*
Map 14.—*S.* sp. n.

changed and the division between them altered, so that the Damer reach extends to Kareima and thus includes an additional series of rapids.

The Imatongs Area.

This area contains three mountain ranges which form part of the Eastern and Southern zoogeographical Province. In the Imatongs the R. Kinyeti flows steeply through thick forest, and at an altitude of 1100 metres (Katire) some *S. dentulosum*, *S. lepidum* and *nigritarsis* and a few *S. adersi* have been found, and at 1400 metres (Gilo) *S. lepidum* and *S. nigritarsis*. In a small stream on the Didingas at 1980 metres (Nagichot) *S. dentulosum* and *S. nigritarsis* occur.

The Yambio-Yei and Raga-Torit Areas.

West of the Nile.

This area, in which onchocerciasis is an important problem, is mainly grass woodland sloping from the Nile-Congo watershed northward. Numerous small streams flow into a number of rivers which, passing at first through rocky beds and later along muddy or sandy courses meandering between grassy alluvial flood plains, either enter the great swamps or, in some cases, dry up before they reach them. In the dry season most of these streams and rivers dry up or become mere chains of stagnant pools. During a tour in February and March, 1946, from Juba through Yei, Yambio, Wau, Raga, Aweil and Tonj to Amadi so little running water was seen that larvae or pupae of SIMULIIDAE could only be found at Yei, Maignbara, Rafile (R. Bo), Wau, Kuru and Tonj. Only at Yei and Maignbara was the flow strong enough for many larvae to exist. At Maignbara and Khogali many *S. damnosum* were biting in February. The Aga Falls are 1100 metres above sea level, and at their foot *S. lepidum* breeds in large numbers. During the rains *S. damnosum* is a troublesome biter on the Sueh and several other rivers.

East of the Nile.

The country has a relatively low rainfall and few streams. At Torit the R. Kinyeti passes over some small waterfalls before flowing into the Nile swamps downstream. The falls appeared to afford suitable conditions for *S. damnosum* and other species, but no Simuliids could be found during a careful search. The river is reported to have ceased flowing at this point once in the last 25 years. If *S. damnosum* ever existed there it has probably died out and been unable to colonize this place, remote as it is from other lowland rapids. The absence of *S. adersi* is less easily explained, as it occurs upstream in the mountains.

The Nuba Hills Area.

This is an area of isolated rocky hills and ranges which rise abruptly from the plain. In the rains numerous streams flow into rivers which lose themselves in the plains and very seldom reach the Nile. A few small streams are perennial. The isolated Simuliid "fauna" comprises only two species—*S. adersi* and *S. ruficorne*.

The Marra Mountains Area.

These mountains are a high isolated range some 1350 km. (840) miles from the Imatongs, the nearest mountains of comparable height in the Sudan. *S. dentulosum*, *nigritarsis* and *medusaeformis* occur, the first two being also found on the Imatongs.

The Gezira Area.

This clay plain between the Niles is the site of the Gezira Irrigation Scheme, in the small weirs of which *S. adersi* and *S. damnosum* are sometimes found breeding on fragments of vegetation. *S. damnosum* is very occasionally found biting, having bred in sluices or in the Blue Nile. It was reported to be troublesome at Wad el Mubarak in 1933 and at Murebiya in 1934, and had probably bred at these places.

The Fung Reach.

S. damnosum occurs at the Damazin Rapids and the Sennar Dam. At Sennar it breeds in water flowing below the downstream face of the dam and causes much annoyance. In the winter of 1939–40 it was at times numerous enough to prevent football. Becker (1923) encountered *Simulium* (*griseicollis* ?) among bushes near the Nile at Sennar from 18th to 27th February, 1914, in the afternoons, when they were abundant and very troublesome, crawling particularly into the ears and being very difficult to drive away.

The Rufaa Reach.

The Blue Nile flows in a steady broad stream, and at low water the flow is sufficiently rapid in certain shallow places for a certain number of Simuliids to breed on stranded logs and sticks, on sedge plants (*Cyperus rotundus* L.), and occasionally on *Salix* sp. and *Polygonum* sp. At Wad Medani, where the writer has lived for several years, there is a broad ledge of rock formed by calcareous concretion which is overgrown with sedge. When the river falls in winter to a particular level many *S. damnosum* and *S. griseicollis* and a few *S. adersi* can breed on the sedge, but when the level drops further many pupae die. *Simulium* larvae have been found at Wad Medani between 29th December and 26th April, and *S. damnosum* biting between 31st October and 30th March, but they are seldom noticeable except near the river.

The Damer Reach.

The steepness of the average slope of this reach, likened in the introduction to the upper part of a river, and the volume of water imparted to it by the combined Blue and White Niles, make it an important area for Simuliids. The Fourth and Fifth Cataracts and the Sabaluka Gorge are in this desert reach, and between them are minor rapids and long stretches of placid water flowing between alluvial flood plains. After the flood which follows the rainy season further south the river level falls in winter, but the drop is for a time reduced by the opening of the Sennar and Jebel Auliya Dams upstream. It is possible that the construction of a dam above Merowe may reduce breeding downstream of Abu Hamed (Hurst, Black and Simaika, 1946 : 103).

S. damnosum and *S. griseicollis* occur at many places and the former is reported to be troublesome at Abu Hashim, Shereik, Abu Dis (named after sedge of *dis* on which Simuliids frequently breed), Nadi, the Fourth Cataract, Abu Hamed and Hamdab. In this arid climate the rocks in the cataracts are polished and bare of vegetation, so that *S. damnosum* breeds mainly on sedge. In some places the inhabitants regard sedge as the source of the flies. It is reported that at Abu Dis kunteb are numerous from December to April, and that at Nadi they are particularly troublesome and have been sufficient to prevent labourers from working near the river. At Shambat nimitti were bad enough in 1936 to necessitate the use of head nets.

The Dongola Reach.

General description and the nimitti belt.

The Nile is navigable from Kareima to Kerma, beyond which it passes into the Third Cataract and through a long rocky stretch with isolated rapids to the Second Cataract, whence another navigable reach continues into Egypt. This almost rainless area is subject to a great range of temperature.

The main *S. griseicollis* area is ill-defined owing to range of flight and seasonal variations, but its southern end is in the neighbourhood of Kulud, near which the current increases and there are many clumps of sedge. Its northern end is near Wawa. Nimitti are only moderately numerous in very placid reaches, and abundant where there is an easily perceptible current. In rapids they are less noticeable than *S. damnosum*. The nimitti belt seems to have extended upstream from Debba since King's visit in 1906. Some years later a retired official chose to settle at Mansorkotti, but was later driven away by nimitti.

Breeding-places on mud.

The Nile even at low water is a large river; the mean discharge at Wadi Halfa between December and April varies from about 50 to 180 million metric tons a day, and the channel is about 600 to 1300 metres wide in the Dongola area. The fact that *S. griseicollis* breeds in profusion on moderately hard mud suggests the reason for the vast numbers of the species, and some facts about the distribution of this mud may be noted. An Egyptian coin minted in 1860 was found embedded in a typical bank of it (Plate I, fig. 1), and enabled the age of the mud to be estimated at between 50 and 80 years. It seems not improbable that in the course of time mud deposited below the high-water level becomes impregnated with some substance which gives it a consistency hard enough to resist erosion long enough for *S. griseicollis* to breed on it. In the Dongola Reach the Nile follows a relatively straight course, with few meanders, and often deposits mud on both sides. Erosion and deposition are very rapid, and large islands form and disappear in a few years. In many places it is dangerous for a boat to approach the bank owing to frequent falls. Pupae are often found in cracks of the mud and beneath fallen boulder-like pieces. Rapid erosion is continually producing fresh breeding surfaces, and leaves small promontories past which the current is swift enough for Simuliid larvae and pupae.

Large numbers of *S. griseicollis* and many *S. damnosum* breed on clumps of sedge, the pupae clustering particularly on the flower-heads of plants trailing

in the current. In this district where fodder is scarce even sedge is used for feeding animals, and people venture into the rapids, wading or in canoes, to gather it. Much sedge remains, but even if it were all removed, the effect on *S. griseicollis* in many places would only be the destruction of thousands out of the millions which exist.

King (1923) considered that *S. griseicollis* bred in the rapids north of Kerma, and were carried in enormous numbers by the wind as far as the bend of the river at Debba. If these rapids were the main source of the nimitti the phenomenon might be of great practical importance in planning control measures. In the present writer's opinion, however, although wind carriage may be important, local breeding is responsible for very large numbers of the nimitti. Great numbers have been found breeding in the relatively placid Debba-Dongola stretch of river, and many breed at Wad Medani far from any rapids. On the other hand there are cataracts where *S. griseicollis* is not a serious pest. Furthermore, as mentioned above, nimitti have become troublesome at Mansorkotti, east of the bend of the Nile, possibly owing to a local change in the current.

The nimitti season.

This is variable, but it appears that there is usually a slight outbreak about December and a main outbreak about March. It seems probable that as the river level falls after the annual autumn flood the water becomes clear enough for breeding and in some places sedge is exposed. Breeding probably then starts, but is soon retarded by the cold of winter. Presumably in the spring the rising temperatures accelerate breeding, and the further fall in water level exposes more breeding surfaces. The number of adults increases until they are apparently killed off by the hot dry winds of summer. A possible parallel occurs in the central Sudan, where the number of larvae of *Anopheles gambiae* increases rapidly in March, while the number of adults decreases. *S. griseicollis*, being a diurnal insect, is even more exposed to the adverse atmospheric conditions.

The nimitti season occurs at the time of the flowering of date trees and, as in Brazzaville (Roubaud and Grenier, 1943), of mangoes.

The effects of the bites of S. griseicollis *on man and animals.*

Nimitti cause intense annoyance and much irritation to man by crawling over the skin in large numbers and biting. Children often develop sores behind the ears from scratching. When nimitti are abundant they prevent agricultural work, and drive people to shelter beneath sheets indoors in the afternoons. A few people have been known to remain indoors for several weeks on end during a bad nimitti season. Many people wear head nets, long sleeves and long trousers as a protection, but the latter cannot be worn out of doors in summer owing to the heat. People who visit Dongola often arrange their programmes of work to avoid the nimitti season, and many residents arrange to do outdoor work on windy days when there are few nimitti. About 1903 the capital of the former Dongola Province was moved from Dongola to Merowe, and the prevalence of nimitti at Dongola is said to have been a contributory cause. Residents are much less annoyed by attacks of moderate numbers of nimitti than are visitors.

Mass biting by nimitti is said to cause the death of chickens, turkeys and pigeons, and occasionally donkeys. At times cattle, horses and donkeys can only feed by night and the milk yield of cattle is said to be affected. They are sometimes kept in dark shelters for protection.

Repellents against nimitti.

The inhabitants often anoint their skin with sesame oil, and wear smouldering rope on their heads (Plate I, fig. 4) or carry tins of smouldering cow dung. Some use smoke fires to protect their animals.

The difficulties of attacking the aquatic stages and the expense of area-spraying of residual insecticide against adults would be such that large-scale use of repellents may prove the most feasible means of alleviation. Preliminary field tests with liquid undiluted dimethyl phthalate gave promising results against *S. griseicollis* and *S. damnosum*. One traveller who used this repellent when passing through a cloud of nimitti described the effect as the formation of a cylinder of the insects which surrounded him without biting. They alight on the skin for an instant before being repelled. Several conditions favour the employment of repellents, and will, it is hoped, enable the agricultural population to afford to use dimethyl phthalate as the main measure against Simuliids. Since the desert air is dry and Simuliids are abundant in the cool season sweating is not an important hindrance to the action of the repellent. Unless the insects are very abundant one need only anoint the head against nimitti and the legs against kunteb. In cold weather repellents are unnecessary in the first hours of the day. Sandflies (*Phlebotomus papatasii*) are very troublesome at times and are likely to increase the use of repellents.

Supposed relation of nimitti to the date crop.

Many males of *S. griseicollis* were observed on mango flowers at Dongola in February, 1947. They frequently probed near the base of the pistils and appeared to be feeding. Others probed the outer surface of the sepals of unopened buds, and could be seen under a lens apparently inserting the proboscis into the tissue of the sepals. Many of the sepals had small dark brown spots, possibly scars of old punctures. Females occasionally probed the flowers. No Simuliids were seen on various other flowers. Roubaud and Grenier (1943) have recorded *S. griseicollis* visiting flowers and fallen fruits of the mango and a plant called karite.

In view of these observations it is interesting to note that some date growers, and a number of mango growers, consider that large numbers of nimitti, appearing as they do at the date-flowering season in Dongola area, cause a reduction in their crops. Some say that they damage the male flowers or the female flowers. Others say that the almost intolerable attacks of clouds of *S. griseicollis* spoil the work of the boys who climb the tall trees with bunches of male flowers, past the barrier of sharp spines at the tops of the trees, and carry out artificial pollination. On the other hand, some people consider that the nimitti do not affect the trees, and some even say that the nimitti improve the crop by increasing pollination. The female date flowers are not visited by bees (Mason, 1925), but the nimitti probably settle on them as on most other objects. There is no definite evidence of *S. griseicollis* having any effect on the crops,

and it seems conceivable that the above-mentioned theory may have resulted from simultaneous effects produced on the dates and nimitti by different river levels. A low river may result in more nimitti (by exposing more of the river bed), and is known to reduce the date yield (Mason, 1925). The conflicting theories may have arisen under different conditions of date culture.

Other Areas.

During a brief visit to the Gugi Rapids in March, 1946, very few Simuliid larvae could be found, and biting Simuliids were, surprisingly, apparently unknown. A few Simuliids have been found in the Nile just above Juba.

S. damnosum probably occurs at Wan Alel, where a river passes over rocks in otherwise flat clay country and onchocerciasis is common (Bryant, 1935).

In the Sadd area a few Simuliid larvae have been found on the inner side of leaves of *Phragmites* trailing in the Nile at Mongalla.

The finding of *S. griseicollis* at Umm Inderaba has been discussed above.

The same species has been found at Jebel Auliya, presumably breeding below the dam.

SIMULIIDAE have been found on the Atbara and Rahad rivers, as shown in Maps 3, 6 and 8.

Near Erkowit is one of the few perennial streams in the Red Sea Hills. Many pupae were collected in it, all *S. ruficorne*.

SUMMARY.

The general distribution of SIMULIIDAE in the Sudan is discussed and the 15 known species listed. *S. damnosum* is probably the vector of human onchocerciasis, which is a serious problem.

Some early nineteenth century notes are quoted.

Information on the distribution of the species and on the bionomics of *S. damnosum* and *S. griseicollis*, the two troublesome species, is recorded.

The SIMULIIDAE of various areas, particularly the south-west and the north, are discussed.

ACKNOWLEDGMENTS.

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